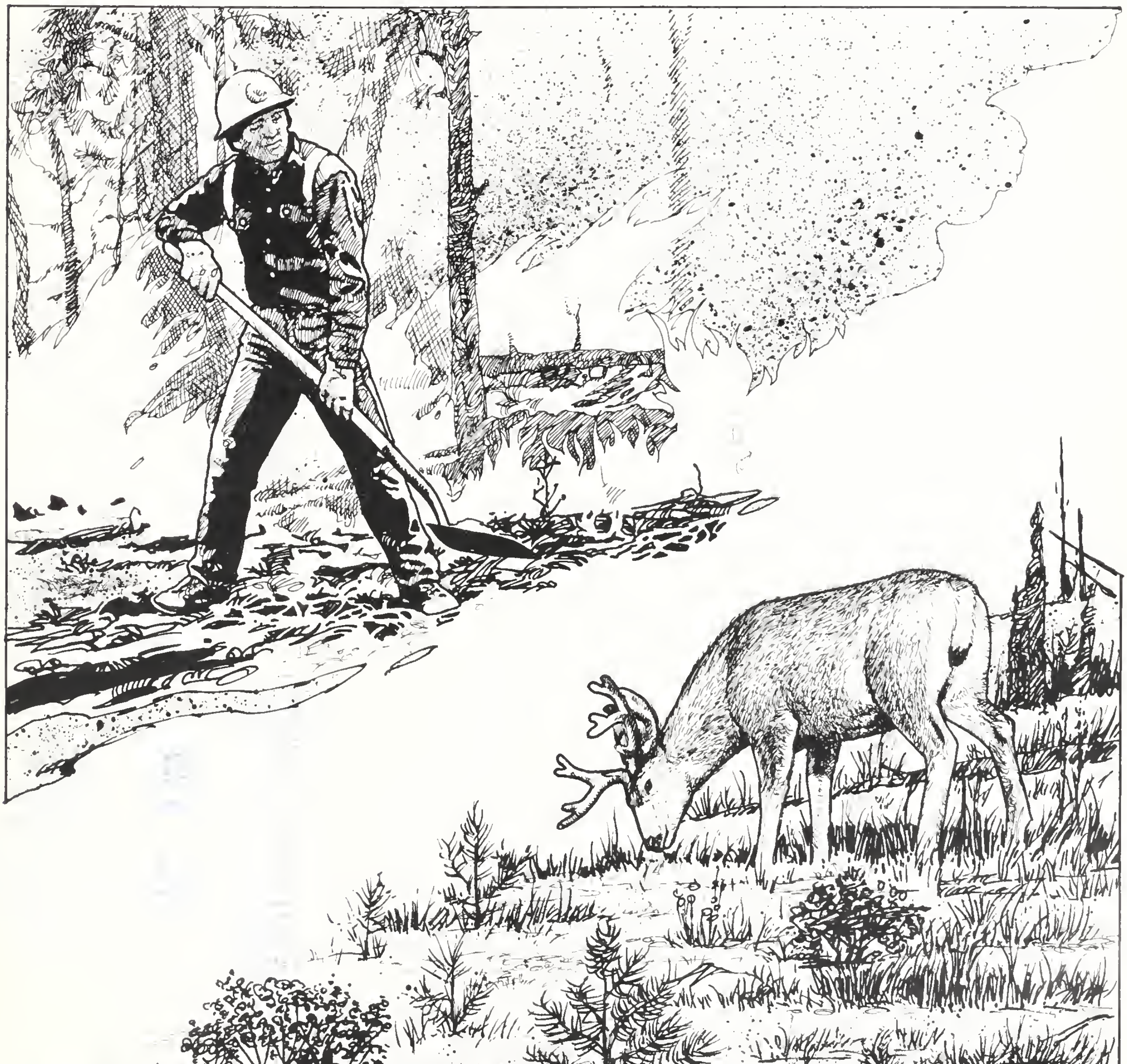
United States
Department of
Agriculture

Forest Service

Fire Management Notes

Fall 1982
Volume 43, No. 4



Fire Management Notes

An international quarterly periodical devoted to forest fire management

United States
Department of
Agriculture

Forest Service

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Contents

Erratum

Change that to IOWA!

A photo of Park Ranger Chad Eells carving a Smokey Bear statue from a cottonwood tree appeared in Vol. 43, No. 3 of *Fire Management Notes.* We mistakenly reported that Ranger Eells was from Wisconsin. He is from Iowa.

Fire Management Notes is published by the Forest Service of the United States Department of Agriculture, Washington, D.C. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through September 30, 1984.

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Disclaimer: Individual authors are responsible for the technical accuracy of the material presented in Fire Management Notes.

Send suggestions and articles to Chief, Forest Service (Attn: Fire Management Notes), P.O. Box 2417, U.S. Department of Agriculture, Washington, DC 20013.

Cover: Two equations for predicting the cost of prescribed burning for habitat management are described on p. 20.

The Dilemma of Flame Length and Intensity

Von J. Johnson

Research Forester, USDA Forest Service, Southeastern Forest Experiment Station, Southern Forest Fire Laboratory, Macon, Ga.

The vertical dimension of flames produced during forest fires is commonly used by fire managers to estimate fireline intensity. Such usage is supported by the well-established relation (*3*):

$$L_f = 0.45\ I^{0.46}$$

Where I is fireline intensity in btu/ft/sec with flame length (L_f) in feet. Detailed application procedures are described by Rothermel and Deeming (*6*). Accumulated evidence, both theoretical and empirical, substantiates an exponential relation between flame length and intensity. For example, work by Thomas (*7*) indicates a flame length proportional to $I^{2/3}$. Nelson (*5*) shows similar association between I and L_f for both backing and heading prescribed fires:

$$L_{f_b} = 0.21\ I^{2/3}\ (\text{ft})$$

$$L_{f_h} = 0.27\ I^{1/2}\ (\text{ft})$$

Two-thirds power of I is also identified by Van Wagner (*9*) as proportional to crown scorch. The observation of flame length is used to predict I in training fire behavior officers (*2*, *8*). In addition, L_f is equivalent to the Burning Index of the National Fire Danger Rating System (*4*). Clearly then, current use of the L_f/I relationship pervades most fire management activities requiring assessment of behavior and effects.

Flames are random, pulsating, transient phenomena. Some of their dimensions (length or height) may be captured for a specific instant with high-speed photography (*1*), or they may be observed as an apparent spatial average per unit of time. However, such instantaneous or averaged values for L_f are not necessarily representative of the quantity used to derive its relation with I. And, whether I is tractable to validating field measurements over its total range is also uncertain.

Fireline intensity may be estimated not only with L_f but by Byram's defining equation (*3*):

$$I = Hwr\ (\text{btu/ft/sec})$$

Where: H is the heat value of fuel in btu/lb,
w is the consumed fuel in lb/ft^2, and
r is the rate of spread in ft/sec.

Field estimation of I requires measurement of H, w, and r. In nonuniform fuels, different observation techniques, sampling procedures, and statistical treatment of data contribute to the wide natural variation in the calculated value of I.

Heat value, usually assumed as a single quantity between 4,000 and 9,000 btu/lb is actually different for each component of a fuel bed and its condition; i.e., bark, leaves, cones, whether they are wet or dry, state of decomposition, and species of parent material. Empirical derivation of a proportional value for H is obviously a formidable task, so a putative value of 9,000 is often used. Individual fuel-loading samples, both preburn and postburn, needed for estimating w may vary by factors of 0.25 to 2.5 within a single burn area depending on sample size. Rate of spread is seldom at a steady state; its dimensions vary in both space and time; it is evident that the characteristic statistic for r is elusive.

Thus, a transient phenomenon (L_f) is used to derive a highly variable behavior parameter (I), and neither of them is simple to measure accurately in the field.

Estimating Flame Length in the Field

The trial of visually estimating flame length was conducted on the Huron-Manistee National Forest in Michigan in 1978.

Ignition of two piles of jack pine slash, roughly 50 ft in diameter and 8 ft high, was on the downwind one-third of their perimeter. Visual estimations of both maximum and minimum flame lengths (fig. 1) were made during the first 30 sec and repeated at 5-min intervals. As the fire spread through and finally engulfed the piles, the depth of fuel bed gradually collapsed. Consequently, some of the

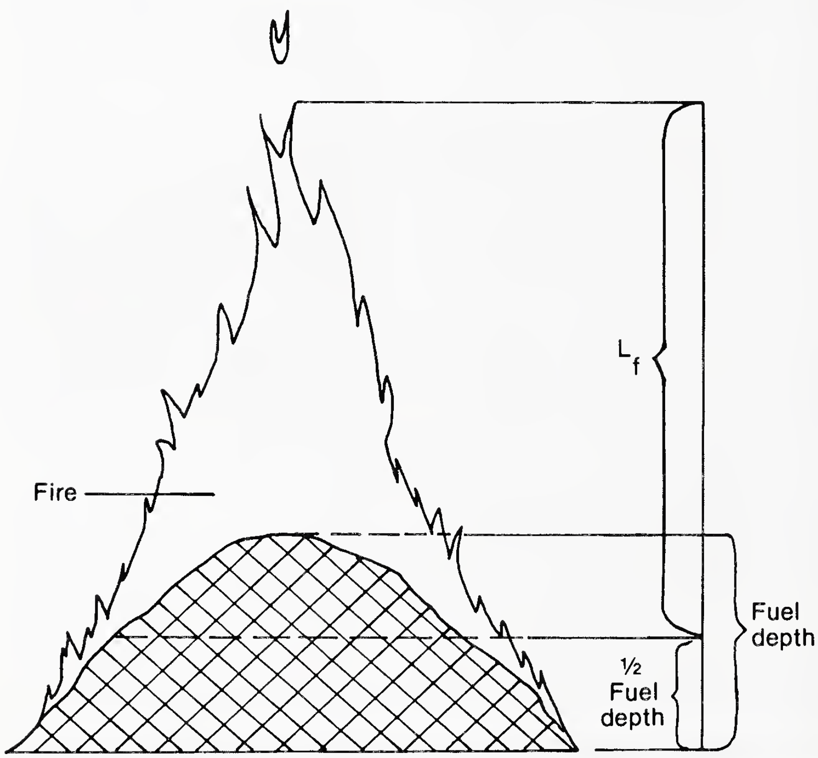

Figure 1.—*Length of flame from the middle of the burning fuel bed to the coherent top of the flame.*

flame lengths were observed as less than one-half the original fuel bed depth. Over 450 independent 30-sec observations were recorded by 35 two-student teams from Michigan State University. Thus, a maximum of 35 simultaneous observations were recorded for each 5-min interval throughout the 2-hr total elapsed burning time.

The highest average maximum flame length observed during a single 5-min interval on Fire No. 1 was 25 ft and ranged by factors of 0.28 to 1.6. The highest average minimum flame length was 12 ft with a factor of 0.04 to 2.6. Both the highest maximum and minimum flames were observed during the sixth interval—about 30 min after ignition. Location of the observers with obstructed views may have contributed to the greater range in minimum flame lengths. Converting L_f observations to I (*3*), assuming a line fire configuration, provides a different perspective.

Fire No. 1

Flame length		Intensity
Feet		*Btu/ft/sec*
25	Average maximum	6,200
12	Average minimum	1,260
	Mean	3,730

Range during 1 hr 40 min elapsed burning time 1.26 to 16,984

Fire No. 2 was ignited 45 min after No. 1. Both the highest average maximum flame length (L_f = 19 ft) and the highest average minimum flame length (L_f = 9.5 ft) occurred about 25 min after ignition. Mean maximum observations ranged by factors of 0.41 to 1.6 and mean minimum by 0.21 to 2.5 during a single interval. Converting L_f to I yields:

Fire No. 2

Flame length		Intensity
Feet		*Btu/ft/sec*
19	Average maximum	3,400
9.5	Average minimum	760
	Mean	2,080

Range during 1 hr 25 min elapsed burning time 1.26 to 12,712

The implied fireline intensity profiles were similar for both fires (fig. 2) with two peaks in intensity. These averages represent the mean of the total maximum and total minimum observations during each 5-min interval. Pooling observation data for longer intervals, i.e., 10,

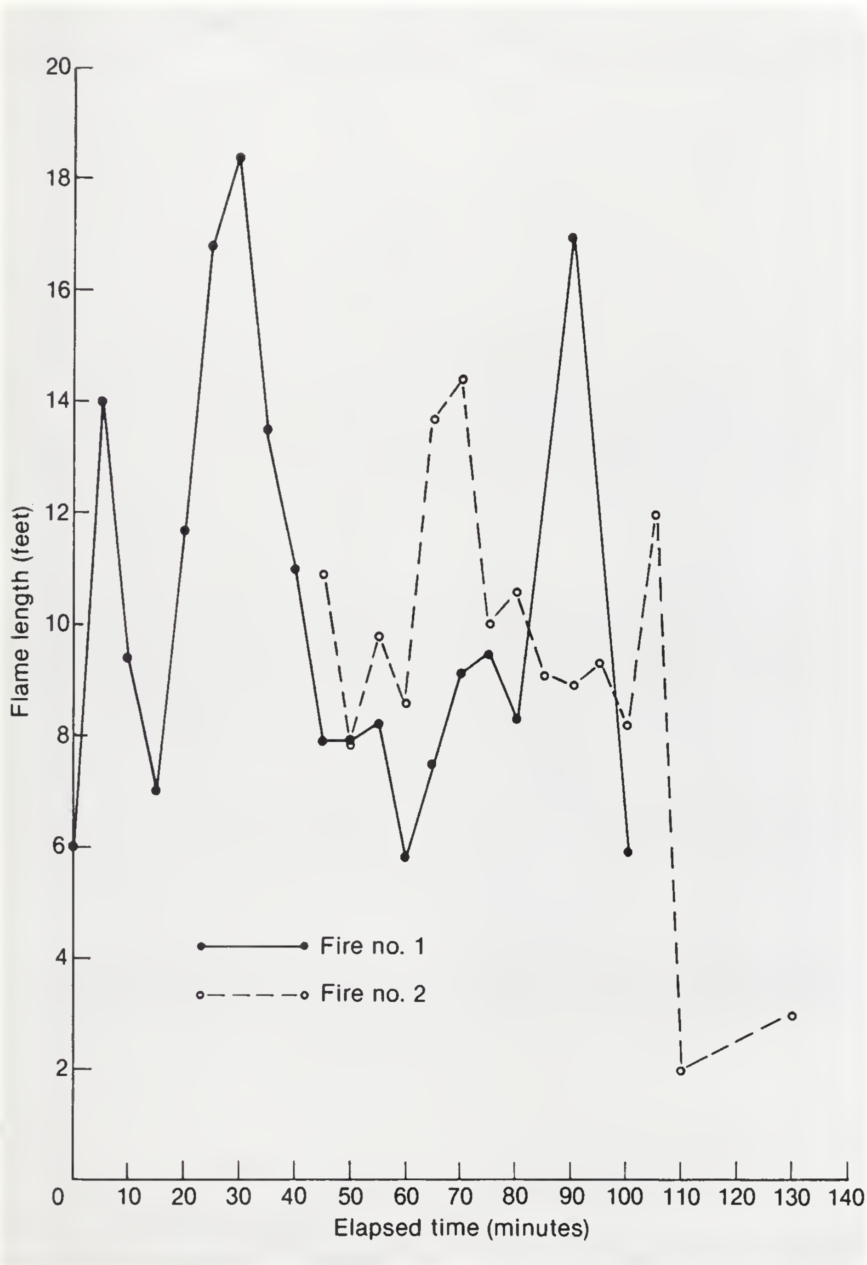

Figure 2.—*Average flame length at 5-min intervals.*

30, and 60 min, progressively reduces variations (figs. 3, 4). This is analogous to extending the observation interval. Total heat output per unit area, the mean heat release derived from flame lengths during various observation intervals, total burning time, and area of burn (1,960 sq ft) are influenced by observation interval:

Observation interval	Fire no. 1	Fire no. 2
Minutes	*Btu/ft²*	
5	3,210	1,720
10	3,130	1,750
30	2,960	1,800
60	2,530	1,830

The 60-min observation interval significantly reduces apparent heat release from the 5-min interval by 21 percent on Fire no. 1, and increased the rate of Fire no. 2 by a nonsignificant 6 percent. The heat output unit, as derived here, is for illustration only and is not indicative of real values since no estimate was made on weight of fuel burned. Spread rates of a line fire are required for a realistic estimation of heat output per unit area.

Other statistical characteristics of these data, such as median and 50th percentile, show similar burning profiles. The median flame lengths during the peak burning periods (25 to 30 min from ignition) for both fires were about 1 ft higher than the average of the 50th percentile value.

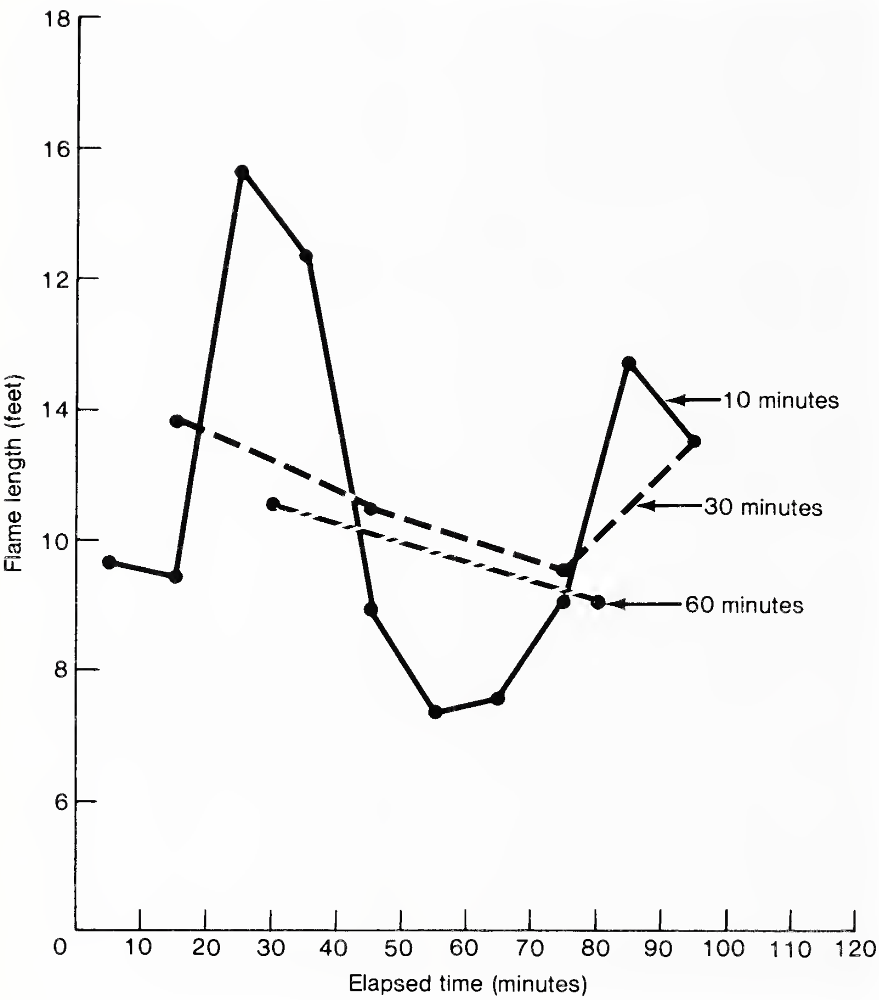

Figure 3.—*Fire No. 1—average flame lengths at 10- , 30- , and 60-min observation intervals.*

Although brush piles are probably the least complex and easiest to observe, they provide an example of the difficulty in using L_f to estimate I, particularly at higher intensities. Greater variation of L_f and I occur on prescribed or wildfires involving nonuniform fuel beds or more than one fuel strata, particularly at higher intensities.

Recommendations

This example illustrates the dilemma of using analytically derived models for empirical decisions. The numbers are well behaved but the phenomena are not. However, better substitutes for the models have not yet been developed.

The relation between flame length and fireline intensity is theoretically sound, but both L_f and I are difficult to measure under field conditions. When either I or L_f is to be used to evaluate fire behavior or effects, the methods used for measuring or analyzing should be specified. As a minimum, this should include:

- Estimation techniques (distance measuring devices, photography, etc.).
- Period and frequency of observation.
- Location of observations in juxtaposition with the dependent characteristic, e.g., flame-length measurements should be paired with scorch heights at the same location.
- How independent statistics, i.e., mean, median, percentile, etc., were derived.

If time permits, both methods of deriving fireline intensity (flame length and rate of spread × burned fuel) should be used independently at the same location.

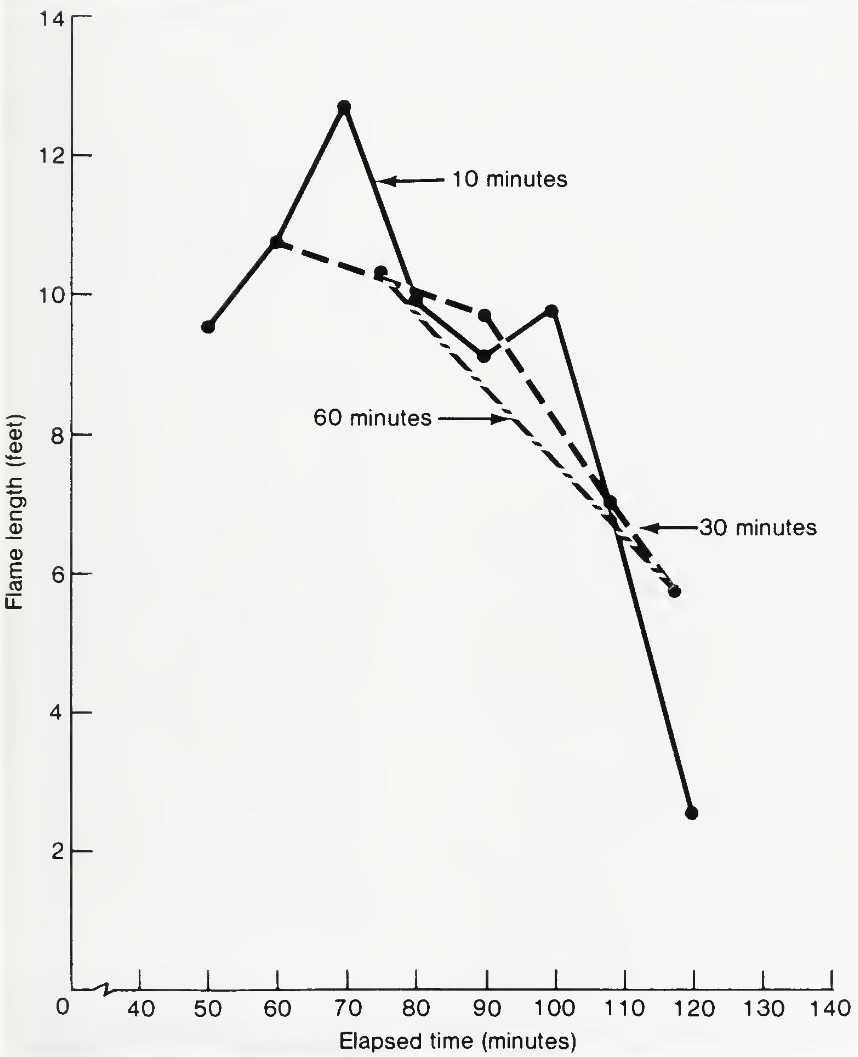

Figure 4.—*Fire No. 2—average flame lengths at 10-, 30-, and 60-min observation intervals.*

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The National Interagency Incident Management System

Marvin Newell, James Whitson, and Francis Russ

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The National Interagency Incident Management System (NIIMS) is a model designed to aid emergency service organizations in their management of routine and full-scale, complex emergencies. It was adopted in principle by the National Wildfire Coordinating Group in 1981 as an all-risk incident management system.

FIRETIP (Firefighting Technologies Implementation Project) has the lead in transferring the technologies associated with NIIMS to State and local agencies involved in fire protection. The FIRETIP Staff agreed to discuss the organization and the strengths of NIIMS with Fire Management Notes (FMN).

FMN. For several years now most Federal agencies with responsibility for wildland management and some States have been successfully operating under the Large Fire Organization (LFO) concept; why change to NIIMS?

FIRETIP. The Federal wildland protection agencies and some States have successfully used the LFO for many years. This system, however, has been rather rigid. It has strict qualification standards and physical requirements. Most State and local fire protection agencies have not accepted the position titles or terminology associated with the LFO. NIIMS overcomes the limitations of LFO by providing for the development and use of local standards, and by using uniform terminology and titles meaningful to all agencies.

We stress the application of NIIMS to wildfires; however, more and more fires require the efforts of both structural and wildland firefighting forces where urban sprawl has crept into wildlands. We see NIIMS as a more flexible system that greatly increases the ability of emergency organizations to work together and share resources for effective fire suppression.

FMN. You refer to uniform terminology and flexibility, but how does that make NIIMS superior to LFO?

FIRETIP. NIIMS allows agencies to more easily share resources because they talk the same language and use the same kind of emergency organization structure. The agencies that have accepted the system will have a common understanding of how it functions and how they fit into an incident in another jurisdiction. When agencies talk with each other and work together to support one another, they will become more efficient and effective. NIIMS encourages interagency planning to avoid confusion in multijurisdictional incidents.

FMN. We have been talking about the NIIMS model in general terms. How exactly is it organized?

FIRETIP. NIIMS consists of five subsystems.

- The on-the-scene management structure is called the Incident Command System (ICS). It includes operating requirements and interactive components.
- NIIMS recommends standardized training to support the effective operation of the ICS.
- NIIMS recommends personnel qualifications and certification for those resources that are expected to have regional or national application, yet allows for the development of local minimum standards to meet local needs.
- NIIMS includes a publications management subsystem to develop, publish, and distribute NIIMS materials.
- Another branch of NIIMS coordinates other supporting technologies, such as orthophotomapping, communications planning, multiagency coordination, and outlines a decisionmaking process for emergency situations.

FMN. NIIMS is called an "all-risk" system. Does this mean that everyone is trained to handle every type of incident?

FIRETIP. No. "All-risk system" means that the organizational structure can be used to manage any incident, large or small, from initial response to full control by

expanding organizational structures as needed. The management concepts within NIIMS apply to small, single-agency incidents or large, multiagency incidents. It is true, however, that individuals or agencies may be requested to work in a support role on incidents which they are not specifically trained to handle.

FMN. Implementing a new system is going to cost money, and most of the agencies involved are undergoing budget cuts and personnel reductions. Won't this new system have a tremendous financial impact on most agencies?

FIRETIP. There will be some immediate costs associated with NIIMS; however, these costs may not be entirely unique, since the costs of operating the present system would also go on. Initially, training costs will increase. However, subsequent costs would fall within normal training budgets. Recently designed, self-taught, courses should help eliminate the need for some of the travel previously associated with training. And, in many cases it will not be necessary for each agency to train for every position within the ICS. Cooperating and assisting agencies not previously involved with the LFO could now train some of their personnel for certain positions in support of the management system.

We feel that the costs of training will be more than offset by the increased quality, availability, and effectiveness of firefighting personnel.

FMN. How much retraining will adopting NIIMS entail?

FIRETIP. Qualified people should be able to move into comparable ICS positions with little additional training. They will need to gain familiarity with the management system and the specific duties of the position they occupy. They will not be retrained in how to fight fire, however, but in how to work within the management framework. Many training and information packages are already available, and all training material will be available within 2 years to train new firefighters in the system and to help everyone advance in positions.

FMN. The Large Fire Organization was designed for large fires. Is NIIMS applicable to large incidents?

FIRETIP. One consideration in the development of the NIIMS model was providing a process to meet the demands of small or escalating incidents. Most incidents never reach a point that requires a major expansion of the incident organization. Some do, and they grow beyond the point where a single agency can handle the situation with its own resources. A few incidents may become very large and complex. The command system is designed for routine use by a single agency, as well as the very large complex multi-agency situations.

The organizational structure builds from the "bottom up" so it may be effectively used regardless of incident size or number of resources involved. The flexible NIIMS system does not require a major change over or transition into a different operating system during the incident.

Briefly, this is how it works: On an initial attack, the person in charge is the Incident Commander. He would perform all necessary functions of the system at that level. If the incident grows and more resources are brought in, a senior officer assumes command. This senior officer would perform all functions until the responsibilities for operations, planning, logistics, or finance functions are delegated. As the incident grows, additional positions are filled, ensuring orderly support for the control of the incident. The NIIMS organization is flexible and expands in a logical manner.

FMN. We hope that we have answered some of the basic questions concerning implementation of NIIMS. Future issues of Fire Management Notes will include more articles dealing with its application. ■

Monitoring Aircraft in Flight on Payette National Forest

Deanna Riebe

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Air operations safety depends upon the accurate monitoring of aircraft in flight. Flight plans and scheduled check-ins provide important safeguards, but the hustle of a busy dispatcher's office can hinder the aircraft-tracking process.

Forest Service policy requires all aircraft to be on a flight plan of some sort. Any flight not on a Federal Aviation Administration (FAA) flight plan is required to file a Forest Service flight plan and check in at 20-minute intervals for the duration of the flight (except on a point-to-point flight).

During fire season, the Payette Forest has numerous aircraft in the air at one time, including helicopters, air tankers, smokejumper aircraft, lead planes, local contract aircraft, planes from other forests, and regional aircraft. During the past two fire seasons, the McCall Smokejumper Base conducted approximately 25 percent of the region 4 aircraft use for fire-related activities. This will increase in the future as smokejumper bases merge and the McCall Base's area of protection increases.

With the volume of traffic, the numerous phone calls, and the many other distractions, it is extremely difficult to keep track of all flights and their 20-minute check-in times, particularly during fire season. To improve the situation, the Payette National Forest (NF) has developed an aircraft monitoring system that provides an audible and visual tracking of up to 16 aircraft in flight.

Jim Butler, dispatcher for the Payette NF, designed the Aircraft Status Management System (ASMS), which has provided service for the past 2 years. The ASMS displays a steady green light to indicate an aircraft in flight. Every 20 minutes, a red light flashes, accompanied by an audible 1-second tone. This signals the dispatcher to contact the aircraft if the pilot has not already radioed in. The ASMS enables the dispatching office to more accurately keep track of up to 16 different aircraft in flight at a time.

How It Works

The 16 lights on the ASMS board are activated by 16 corresponding switches on remote control units on the dispatchers' desks. When an aircraft is airborne, a dispatcher activates a green light on the ASMS board. This starts a 20-minute timing cycle for that particular aircraft. When 20 minutes have elapsed, the tone sounds, the green light goes off, and a corresponding red light flashes until reset by one of the dispatchers from a remote control unit.

At this point, if the aircraft has not checked in, dispatch can attempt to make contact. After contact, the system is reset by simply pushing a button on the remote control unit: the red flashing light goes off, and the solid green light comes back on for the next 20-minute cycle.

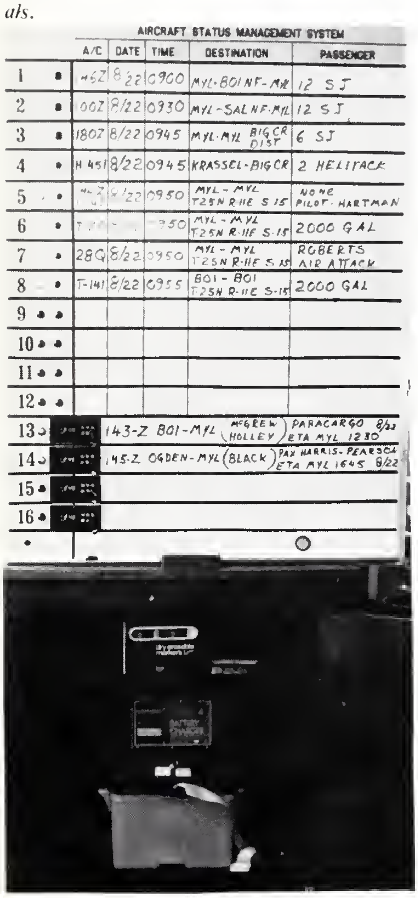
An important feature of Butler's ASMS design is that position check-in times can be less than 20 minutes. If, for example, a pilot checks in at 15 minutes, dispatch can log the position of the plane and reset the system for the next 20-minute cycle in exactly the same way as if a full 20-minute cycle had been completed.

The status display board measures 3 feet × 4 feet. To the right of each of the 16 numbered light positions is a space to write. The melamine-type white board is highly visible; its surface is suitable for marking with special, instantly drying, brightly colored felt pens. Different colors can be used for different aircraft; for example, smokejumper aircraft can be coded red, air tankers blue, helicopters green, and lead planes black.

The ASMS is centrally located within view of all three dispatchers and mounted on a base cabinet that houses a battery, charger, and other materials. Overall height is 7 feet 3 inches. The long-life, high-intensity light bulbs are mounted in such a way to give clear visibility for the full 180° of arc of the display front.

Of the 16 available positions, the top 12 are set on 20-minute maximum timing cycles for local flights within the range of the Forest's communication system. The timing cycles are controlled by a special solid-state timing circuit based on an oscillator timebase. The remaining four are on quartz clocks capable of settings of up to 24 hours.

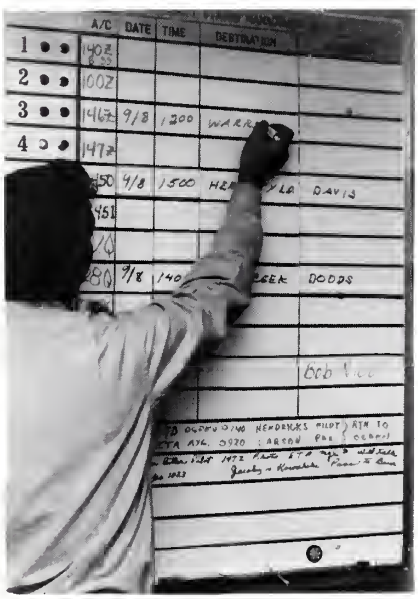
The ASMS display board and cabinet that houses a battery, charger, and other materials.



This allows dispatchers to set Estimated Arrival Times (ETA's) for incoming and outgoing flights.

The device is of solid-state design with the exception of the incandescent lamps. The unit power source is 110V a.c. routed through a battery charger and converted to 12V d.c. power, which operates the unit and also provides a backup system in case of power failure. The unit will operate on the 12V battery system without a.c. power for 2 to 3 days. In the event the master switch should accidently get turned off or a lamp should burn out, the alarms still work because the unit's built-in memory takes over. When power to the lights is restored, the quartz clocks still show the actual time and the 20-minute cycles have not been interrupted.

A dispatching officer fills in flight information on the ASMS display board.



The unit is maintenance free with the exception of the 12V battery which is checked monthly for water level. The battery charger's automatic timer is set to charge only during the working hours of the day and to shut itself off at night. The unit is set up for a 2-minute test mode for all of the 20-minute time cycles. This allows for periodic tests on all circuits to be sure everything is working.

For more information about the ASMS board, contact Jim Butler, USDA Forest Service, Payette National Forest, Forest Service Building, Box 1026, McCall, ID 83638. ■

Drafting Guidelines to Manage Forest Residues

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To make sound management decisions, a forest manager must consider many aspects of the forest and the surrounding environment.

However, the complexity and interactions of all of the disciplines involved in the planning process make it difficult for one person to organize the knowledge and experience needed for land management.

This paper presents a system used to organize existing information, personal experience, and techniques for managing forest residues[1] to meet environmental considerations while providing for the many forest products, esthetic values, and public services derived from forested and range areas. This system was used to develop the Forest Residues Management Guidelines for the Pacific Northwest (*1*) and could be useful in other management disciplines like silviculture, wildlife, and soils to develop guidelines or policy statements that synthesize knowledge and experience about natural resources. Although the method is applicable to any management discipline for any particular location, the example described here deals with managing forest residues in Oregon and Washington.

Formulating Guidelines

The essential part of the "residues guidelines" (*1*) is a list of statements concerning managing forest residues on forests and rangelands. The statements are accessed by a sorting system that considers land ownership, planned management activities, location, and species association types.

The first step is to define the problem. In our case, the problem was how best to manage forest residues to meet the environmental and esthetic concerns voiced by members of many management disciplines in the public and private sectors. To solve the quantified problem, the manager needs to know what the alternative treatment methods are and what effect each has on the resources and disciplines.

To amass all information possible on forest residue, coordinators were selected as chairpersons for technical panels on air quality, diseases, fire management, insects, recreation, water quality and aquatic habitat, silviculture, soils, and terrestrial habitat. The chairpersons selected the members of their panels. Panel members included foresters, scientists, and specialists from several government agencies, as well as private landowners and forest industry personnel. The number of members for each panel varied from 12 on the silviculture panel to 4 on the soils panel.

These panels did the technical work of developing and organizing guideline statements. The panels met concurrently but did not interact. This was done to insure that panel members had the freedom and opportunity to say what they felt was most beneficial or essential for managing their resource or service with regard to forest residue management.

The panel members considered construction, cutting practices, and other activities that create forest residues, including: road, trail, campground, structure, ski run, and utility construction; individual tree selection, shelterwood, group selection, clearcutting, precommercial thinning, and commercial thinning cutting practices; type and rangeland conversion; natural residues treatment, and dying and damaged vegetation removal.

The geomorphology and vegetative associations of a location influence the creation and treatment of forest residues. To reduce the magnitude of generalization because of vegetative and land form diversities, a forest residue type map was used. This map was derived by delineating the area into geomorphic provinces and then dividing each province by timber species association and geomorphic subprovinces. Each panel addressed residue management keyed to each designated forest residue type. The numbering system consists of a series of five digits. The

[1] Forest residues are the unwanted accumulation in the forest of living or dead material resulting from natural causes or people's activities. Forest residue includes slash, excess litter, unwanted living vegetation, and standing dead trees.

Forest residue type map, western Washington.

first two identify the geomorphic province, the third one the timber species association, and the last two the geomorphic subprovince.

For example, the forest residue type number "04101" represents: "04"—Puget Sound Basin Province—the geomorphic province. This Province was subjected to massive continental glaciation that formed an area of low relief broken by mounds, low moraine ridge systems and rounded hummocks, with many lakes included. "1"—Northern Douglas-fir (Douglas-fir, western hemlock, western redcedar, grand fir, Pacific silver fir, red alder, Sitka spruce, bigleaf maple, western white pine)—the timber species association. "01"—Coastal plain—the geomorphic subprovinces.

The management activities selection and forest residue type maps were completed before the panels were convened.

Each statement was documented by panel members with supporting information from literature and deliberations of the experts involved in developing the guideline statements. The statements were documented to provide land managers with additional information and "rules-of-thumb" that make application of the statements easier

and, in some cases, more meaningful; to help policy makers evaluate the basis for guideline statements; to identify the basis for guidelines—either documented research or consensus of specialists—so that it may be compared with conflicting or later information; and to help persons responsible for assigning research and development priorities.

Specificity and the most reasonable possible translations of knowledge into action terms were combined with a degree of risk-taking. The risks were taken when gaps in knowledge were bridged with experienced judgment to frame a suitable guideline statement. The chairpersons of the technical panels convened after all statements had been written and resolved as many conflicts as possible. Unresolved conflicts were referred to two land management decision panels.

Resolving Conflicts

Although nearly all forest owners regard proper land management as a responsibility to society, differences in goals and policies do exist between public agencies and private landowners. Therefore, the next step was to convene two land management panels—one representing public agencies (nine members) and the other representing private industry and forest land managers (seven members). These two panels, composed of experienced line officers with major management responsibilities, met separately; arbitrated unresolved conflicts; and accepted, rejected, or modified each recommended guideline statement to assure that each was administratively attainable. The technical panel chairpersons were present to clarify and defend their particular statements. This final qualifying process resulted in 137 statements relating to public land and 77 relating to private land.

Sorting Procedures

A person cannot readily scan 214 statements and determine which are appropriate for a particular management situation. Therefore, a unique sorting procedure was devised. This procedure considers the manager's planned management activity for a given site and species association, and whether the residues will or may be burned or will not be burned.

The visual management criteria of National Forest System were incorporated into the keying system. The user has the option of inputting this information where public lands are concerned. This sorting procedure is unique to the residue management guidelines (*1*); however, it can be modified or a new one devised for a different situation.

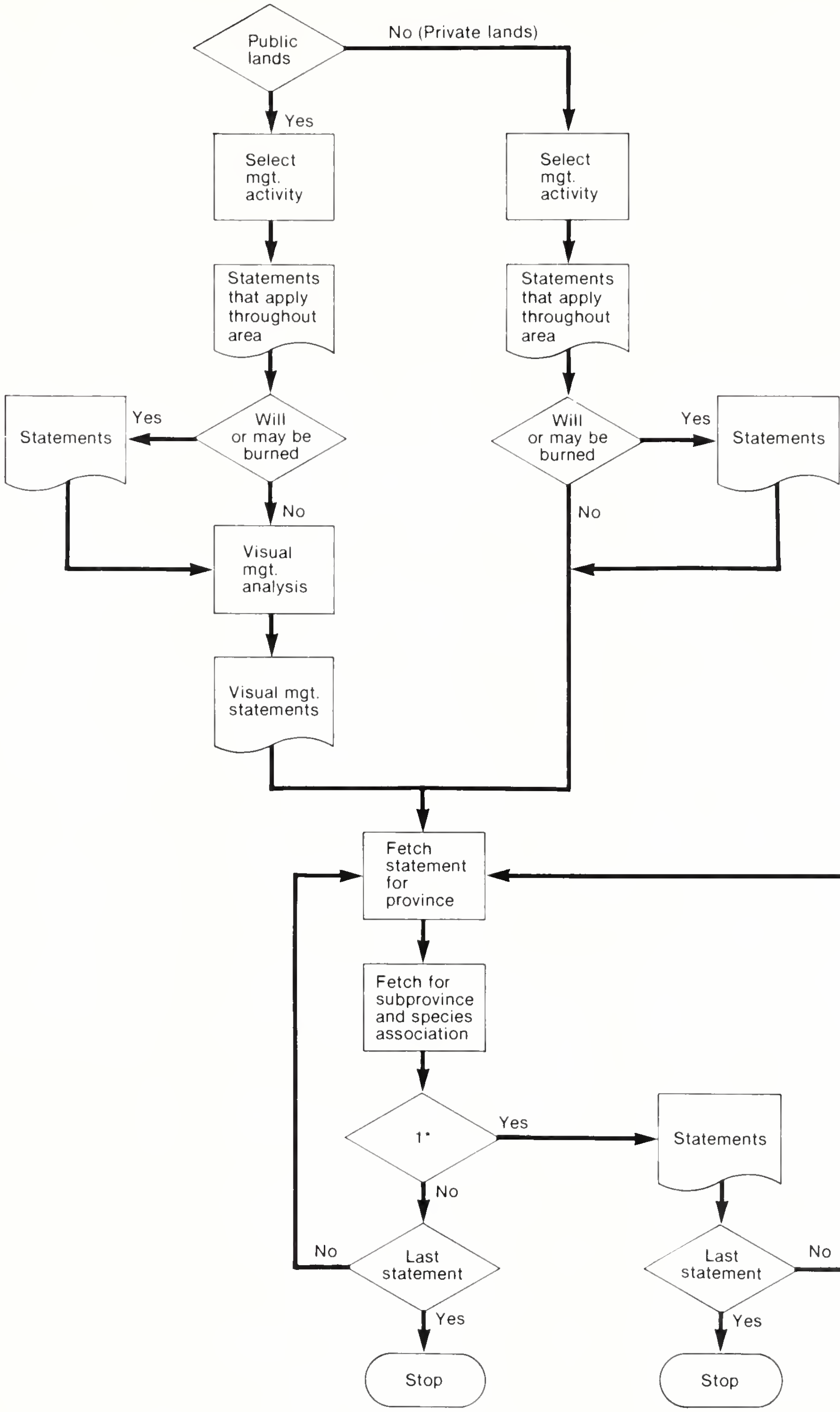
So that this system is suitable for automatic data processing, each statement was numbered for easy retrieval. This is especially helpful for large organizations or firms where decisions are made for numerous timber sale contracts, residue disposal contracts, work assignments, and other forest residue-related work. Initial computer programming for the data processing system can be a straight forward matter adapted for a yes or no type of logic program. In addition to the obvious speed of obtaining a printout of applicable statements, this approach has the advantage of being easily updated when new laws, policies, or better knowledge dictate revisions of any statement.

Numbering the guideline statements makes manual sorting possible, too.

Examples of Guideline Statements

A manager responsible for a parcel of private land within Forest Residue Type Area 04101 (*1*) wishes to shelterwood cut the area with prescribed burning as the option for treating the residue. A perennial stream runs through the area.

The preferred burning prescription is to pile or windrow the material right after cutting. Burning will be done after the first good rain in the fall. Protecting air and water quality are the main concerns confronting the manager.



*Statement found in province, subprovince, and species association

Flow chart of sorting procedure.

A total of 38 guideline statements key out for the manager to consider. Some of the main ones are outlined below.

There are 11 statements pertaining to air quality, with 4 directed at pile or windrow and burn (*1*):

"1.156 Piles or windrows must be mopped up when burning objectives have been met.

1.157 Piles or windrows should be made sufficiently large, consistent with safety considerations, to afford complete combustion within the constraints of piling method, machinery, and surrounding stand.

1.161 Where residues are to be burned in piles or windrows, such must be sufficiently free of dirt and be compact enough to achieve a fire sufficiently hot to meet smoke management objectives.

1.162 Chunking-in, if required, should be done at intervals sufficient to maintain a hot fire."

Two statements in the soils group pertain to machine-piling (*1*).

"1.767 Machine-piling of residues is acceptable provided material of less than 7.6 cm in diameter is left on the ground when:
a. Soil organic matter is less than 3 percent.
b. Soil depth is less than 61 cm.
c. Soil fertility is low.
d. Litter depth is less than 2.5 cm.

1.768 Machine-piling of residues on slopes of over 35 percent should be discouraged except where such operation can be performed without permanent or long lasting soil damage. Exception: In the Siskiyou Province (Province 03), 30 percent should be the maximum in this statement."

Since a perennial stream is present in the area, the manager would consider at least the following two statements for water quality and aquatic habitat (*1*).

"1.951 Generally, stable residue (that which has become incorporated into streambanks and stream channels) should not be removed unless fish migration is blocked or channel erosion is occuring, and then only if approval for the removal is secured from the State fishery agency.

1.952 Man-caused residues will not be allowed to remain in perennial streams, provided their removal will not damage streambanks and channels, when their presence will result in:
a. Streambank erosion before, during, or after stream clearance operations.
b. Reduction of surface dissolved oxygen levels below that required by State law.
c. Deposition of quantities of fine debris in the streambed which will decrease dissolved oxygen levels or reduce waterflow in the subgravel environment below levels required by State law."

Summary

This method of gathering and formulating information about a particular resource provides a framework within which the manager can add local expertise in order to select the best alternatives. This method also presents the best technical knowledge in a readily retrievable form. The success of this undertaking was due mainly to the multidisciplinary team effort made possible by a high degree of cooperation and by a strong motivation on the part of each participant.

This method of synthesizing information is more than just a treatment of environmental issues associated with the management of the concerned discipline. It is also an effective way of organizing the needed skills for developing, disseminating, and applying research findings in a manner that encourages their acceptance and assures their fullest application.

Literature Cited

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Why Programs RxWTHR and RxBURN Won't Run: A Checklist of Common Errors

William C. Fischer, Collin D. Bevins, and Cameron M. Johnston

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Many fire managers use the computer programs RxWTHR and RxBURN (*1*) to help schedule fire use. Often, first-time users of these programs have difficulty getting a successful computer run. Experience during the first 2 years of operational program use by fire managers indicates that most difficulties result from common errors in input preparation. The purpose of this note is to identify these common errors and to provide a user checklist that will prevent their occurrence. This checklist is preceded by a brief description of programs RxWTHR and RxBURN for the benefit of readers who may be unaware of their existence or usefulness in fire management.

Programs RxWTHR and RxBURN

The user-oriented programs RxWTHR and RxBURN allow a fire manager to efficiently analyze climatological data for the purpose of predicting the probable occurrence of desired prescribed fire conditions. Both programs are designed to use the climatological data stored in the National Fire Weather Data Library (NFWDL), located at the USDA Forest Service's Fort Collins, Colo., Computer Center (FCCC). RxWTHR and RxBURN are stored in the region 1 (USDA Forest Service) program library at FCCC and are available via remote terminal or batch processing to all who have access to FCCC facilities.

Program RxWTHR (Prescribed Fire Weather) provides climatological summaries and co-occurrence frequencies of as many as 16 user-selected fire-weather and fire-danger rating parameters. Program RxBURN (Prescribed Fire Conditions) provides analyses of local prescription frequencies based on up to 16 user-defined fire-weather and fire-danger rating prescription conditions. RxBURN estimates not only how often and when desired prescribed fire conditions will occur, but also how long they are likely to persist up to 3 days in the future.

Fire managers interested in using programs RxWTHR and RxBURN should obtain copies of the user's guide and the computer terminal operator's manual from either the Intermountain Forest and Range Experiment Station, Ogden, UT 84401, or the Northern Forest Fire Laboratory, Drawer G, Missoula, MT 59806. Ask for General Technical Reports INT-91 and INT-100, February 1981, by Larry S. Bradshaw and William C. Fischer (*1*, *2*).

Checklist of Common Errors

The following seven questions provide a checklist of errors frequently made by users of programs RxWTHR and RxBURN. A "no" answer to any of these questions indicates an error has been made. A brief discussion of correct procedure follows each checklist question. The appropriate reference to the user's guide (*1*) is given at the end of each error discussion. If the programs won't run after checklist errors have been corrected, review the entire step-by-step instructions in the user's guide or the terminal operator's manual. If it still won't run, contact Cam Johnston at the Northern Forest Fire Laboratory (406-329-3921 or FTS 585-3921).

- Is a **Number of Stations** card the very first input card?
- Does a **Number of Stations** card precede each **Station** card?

Neither RxWTHR or RxBURN will execute if the **Number of Stations** card is omitted. This card must be the very first input card and must precede each **Station** card. A correctly completed **Number of Stations** card contains a two-digit, right-justified entry that indicates the total number of weather stations to be included in the analysis. See step 3a on pages 16 and 25 of the User's Guide.

•Is a **Run** card present?

One run will be made for each **Run** card present in the RxWTHR or RxBURN input stream. If no **Run** card is included, no run will be made. The **Run** card must be the last card in each directive block. It consists simply of the word **Run** in columns 1 through 3. See step 3g on pages 18 and 25 of the User's Guide.

•Is the **End** card present after each RxWTHR summary or Co-occur directive block?

The **End** card must be inserted after the final summary or co-occurence variable is specified, or no run will be made. The card consists simply of the word **End** in columns 1 through 3. See steps 3e and 3f on page 18 of the User's Guide.

•Is the number of prescription factors correctly entered on the **Prescribe** card?

The **Prescribe** card tells how many RxBURN prescription condition cards follow. The number of prescription factors (1 to 15) to be analyzed must be entered in columns 11 and 12 (right justified). For example, if nine or fewer prescription factors are used, enter the one-digit number (1-9) in column 12 of the **Prescribe** card. See step 3f, page 25 of User's Guide.

•Do columns 46, 48, and 50 of RxWTHR and RxBURN **Station Information Cards** have T or F entries?

The message "FTN error on Unit 5" will appear on RxWTHR and RxBURN output if a blank entry appears in columns 46, 48, or 50 of a **Station Information Card.** Both programs expect to find either a "T" (true) or "F" (false) in these columns. If the columns are left blank, the error message is written, the entry is assumed to be "F," and normal processing continues. See step 3b, pages 16 and 25, and table 1, page 17 of User's Guide.

•Does column 46 of the initial RxWTHR or RxBURN **Station Information Card** contain an "F"?

A "T" in column 46 of a **Station Information Card** gives a yes (true) answer to the question, "should RxWTHR or RxBURN repeat use of data processed by a **preceding** station?" Since the **initial** station has no preceding station, an error results and no run is made.

An error will also result if column 46 is coded "T" on **any Station Information Card** when column 48 of the **preceding Station Information Card** was coded "F." An "F" in column 48 gives a no (false) answer to the question "should RxWTHR or RxBURN save the processed data for succeeding stations?" The processed data file cannot be used if it wasn't previously saved.

The rule for using "T" or "F" in columns 46 and 48 is therefore: a "T" must be entered in column 48 of a **preceding Station Information Card** before a "T" can be entered in column 46 of any following **Station Information Cards.** See step 3b, pages 16 and 25 and table 1, page 17 of the User's Guide.

Literature Cited

1. Bradshaw, Larry S.; Fischer, William C. A computer system for scheduling fire use, part I: the System. Gen. Tech. Rep. INT-91. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1981. 63 p.
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Predicting Prescribed Burning Costs of Wildlife Habitat Management

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Two cost equations are now available to land managers for predicting prescribed burn costs for wildlife habitat improvement and assessing the costs of national forest land management required by law. Reported here in summary form are two cost equations that estimate the total project cost and cost per acre of prescribed burns. Our sample consisted of burns conducted for wildlife habitat improvement during fiscal years 1979 and 1980 in Region 1 (Montana and Northern Idaho) of the U.S. Department of Agriculture's Forest Service. Following the equations is a demonstration of how one of them might be used to estimate project cost.

Wild turkey is one species that benefits from prescribed burning for habitat improvement.

A fuller discussion of the methods and data base can be found in Loveless and others (*1*). In summary, virtually all of the prescribed burns funded by wildlife budgets during the time period were included in the data base. Data sources were accounting records such as project work plans and project manager's statements with a questionnaire and a telephone followup to ascertain the physical attributes of the burn because some finer detail was only obtainable from ranger district sources. After eliminating projects with incomplete data, we had a sample size of 61 burns. Our basic hypothesis is that variation in project cost can be explained by knowledge of project characteristics.

The purpose of the equations is to predict or estimate costs. The independent or predictor variables selected are only those which are useful in prediction. We tried to use other independent variables in the equations but found them unimportant in a statistical sense. The independent variables ultimately excluded from the equations were percent slope, aspect, fuel model, distance from private land, season burned, and miles traveled one way. No doubt these variables affect cost but their importance is likely masked by the other variables that were more useful in predicting costs.

Total Project Cost Equation

Project cost is a direct agency expenditure and does not include the cost of project planning and administration or foregone resource value. Total project cost came from the project manager's statement or district records and includes the total of equipment, labor, and material costs for the project.

$$\hat{Y}_T = -260.888 + 3.247\,X_1 - 0.137\,X_2 + 8.082\,X_3 + 608.00\,X_4 + 185.070\,X_5 - 2.938\,X_6 + 6.317\,X_7 - 5.600\,X_8$$

Adjusted R^2 = .83
Standard deviation as percent of mean Y = 36.0
$F_{(8, 52)}$ = 36.46
where:

$\hat{Y}_T$ = Total project cost in 1972 dollars (Implicit GNP deflator) (mean = \$669.36; range \$89.44 to \$2,759.25)

X_1 = Acres burned (mean = 118.74; range 10 to 535)

X_2 = Hand fireline constructed in feet (mean = 415.41; range 0 to 5,610)

X_3 = Labor in hours (mean = 87.85; range 6 to 280)

X_4 = Ignition technique: 0 = headfire, 1 = backfire (mean = .148; range 0 to 1)

X_5 = Type burn: 0 = nontimber, 1 = timber (mean = .674; range 0 or 1)

X_6 = $(X_1)(X_4)$ (mean = 21.541; range 0 to 535)

X_7 = Labor in hours × helicopter: 1 = helicopter, 0 = nonhelicopter (mean = 9.016; range 0 to 184)

X_8 = $(X_3)(X_5)$ (mean = 56.492; range 0 to 280).

Cost Per Acre Equation

Project cost was divided by acres burned to form the dependent variable, cost per acre.

$$\hat{Y}_{PA} = 2.650 + 4.219\ X_1 + 1001.025\ X_2 - 6.956\ X_3 + 7.855\ X_4 - 2.109\ X_5$$

Adjusted R^2 = .93
Standard deviation as percent of mean Y = 38.8
$F_{(5,55)}$ = 164.48
where:

$\hat{Y}_{PA}$ = Cost/acre in 1972 dollars (Implicit GNP deflator) (mean = 9.118; range 1.39 to 99.87)

X_1 = Labor in hours ÷ acres burned (mean = 1.3795; range 0.032 to 7.67)

X_2 = Ignition techniques ÷ acres: 0 = headfire and 1 = backfire (mean = 0.0025; range 0 to 0.067)

X_3 = Ignition technique (mean = .148; range 0 or 1)

X_4 = (Manhours × helicopter) ÷ acres where 0 = nonhelicopter, 1 = helicopter (mean = .0692; range 0 to 1.143)

X_5 = (Labor in hours × type burn) ÷ acres where 0 = nontimber and 1 = timber (mean = .6677; range 0 to 5.0).

The purpose of the first equation (total project cost) is to aid in estimating the cost of a prescribed burn. Managers can use the second equation to compare the costs of burning two different areas or the costs of different approaches of treating the same area. More than 83 percent of the variation in our sample cost data was explained by the independent variables in the project cost equation.

Where cost coefficients are needed in land management planning, the cost per acre equation can be used by expressing characteristics of different analysis areas in terms of size of burn, labor and equipment needs, ignition technique, and type of burn. When done, per-acre cost estimates can be used in land management planning models such as FORPLAN. More than 93 percent of the variation in the sample cost data was explained by the independent variables in the per-acre cost equation.

What the Equations Tell Us

Both equations indicate that per-acre costs decrease with increases in the size of burn. In the first equation total costs increase linearly with burn size. That is, total costs increase by $3.25 for each additional acre burned. This suggests that costs per acre decrease since other factors in addition to burn size affect total costs. The second equation cost per acre shows this relationship. The positive sign of the labor per-acre coefficient means that a slight increase in burn size with a given project labor force reduces the predicted cost per acre. Larger fires reduce cost per acre. Managers and planners must, however, estimate project benefits as a function of burn size, as well as probability of escape fires and subsequent damage before concluding that large burns are more cost effective than small ones.

Use of these equations can be demonstrated by the following example. Suppose that a fire management officer wants to estimate the total project cost of a proposed 140-acre prescribed burn in timber. It is to be a headfire without use

of a helicopter and will require 96 hours of labor and 500 feet of hand constructed fire line. Project costs are first estimated in the equivalent of the 1972 purchasing power of the dollar as follows.

$$\hat{Y}_T = 260.888 + 3.247\,(140) - 0.137\,(500) + 8.082\,(94) + 608.00\,(0) + 185.070\,(1) - 2.938\,(0) + 6.317\,(0) - 5.600\,(96)\,(1)$$

$$\hat{Y}_T = \$538.61$$

To convert the project cost estimate into the current purchasing power of money, a recent Implicit GNP deflator price index value is needed. This can be found in the *Survey of Current Business* or *The President's Economic Report.*[1] At the time of writing, the recent (1st quarter 1982) value of the GNP deflator price index is 201.88. The base 1972 year value is 100. Therefore, the cost of the sample project in current dollars is \$1,087.34 (\$538.61 (201.88 ÷ 100) = \$1,087.34). The means and ranges of the variables are included with the variable definitions so that the user can determine whether the project being analyzed falls in the range of our observations.

[1] U.S. Survey of Current Business, a monthly report of the U.S. Department of Commerce, Bureau of Economic Analysis, and U.S. President's Economic Report, an annual report, are both available from Superintendent of Documents, U.S. Government Printing Office.

In summary, two cost equations are now available to land managers for predicting prescribed burn costs for wildlife habitat improvement. The equations are based upon historical project data. The equations should be of assistance in the management of wildlands.

Literature Cited

1. Loveless, Robert S., Jr.; Flowers, Patrick; Jackson, David H.; and Schuster, Ervin G. Economic analysis of wildlife management opportunities in the Northern Region. Bull. No. 47. Missoula, MT: Montana Forest and Conservation Experiment Station; 1982. 28 p. ■

New System Developed for Appraising Wildfire Effects [1]

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Researchers at the North Central Forest Experiment Station and Michigan State University recently cooperated with the Wisconsin Department of Natural Resources (DNR) to develop a wildfire effects appraisal system that is theoretically correct, practical, and easy to use.

In Wisconsin, wildland fire damage appraisals are frequently used in insurance settlements and legal proceedings. Fire management officials have faced legal arguments with unsupported values based on an older system developed in 1938. That system has severe limitations in appraising immature timber stands, particularly plantations. Another problem with the previous system was that an arbitrary loss of one dollar per acre was assigned for recreation and wildlife and another dollar loss per acre for site deterioration. In addition, specific instructions were not provided for appraising damage to crops, equipment and improvements, ornamental trees, esthetics, environmental quality, or developed recreation sites. To solve these problems, researchers developed a system that could provide accurate wildfire effects appraisal information that is consistent and defensible in court.

Damage appraisal should be done as soon after the fire as possible.

Resource Elements

The new system includes six resource value components: Timber, Wildlife (including undeveloped recreation), Recreation (including effects on esthetics and developed recreation sites), Ornamental trees, Crops, and Equipment and Improvements.

Timber. To evaluate timber losses, the forester appraises merchantable timber at its current value (based on Wisconsin severance tax value) and immature timber at present net value.

Losses of merchantable timber are assessed with the equation:

Loss = average volume per acre × average price by district × predicted mortality × acres burned.

The procedure for immature timber is the same except that average volume is predicted rather than measured, and a discount rate of 6 percent is applied. The harvest date is assumed to be the date at which the stand first becomes merchantable rather than the "opti-

[1] This appraisal system is site specific and should be used within 2 days after suppression of the fire.

mum'' rotation age. Using this shorter period reduces both value prediction problems and the importance of the choice of discount rate.

Because most timber will regenerate naturally to a prefire condition, regeneration losses and replacement values are calculated only for natural red pine, jack pine less than 7 years old, and white cedar stands with a hardwood understory (or more than 30 percent of the stand in other conifers if mortality is greater than 50 percent).

The ''average price by district'' is calculated yearly for timber types by the Wisconsin DNR timber management staff.

To predict tree mortality, researchers combined data from Methven (*2*) and Loomis (*1*) with that collected by the Wisconsin DNR in 1979 to develop two linear regressions for conifers based on percentage of crown scorched and for hardwoods based on the height of bark scorched.

The equations for conifers are:

$$\text{for } x \leq 57;\ y = 1.386 + .401x;\ R^2 = .66^*$$

$$\text{for } x \geq 57;\ y = -75.817 + 1.758x;\ R^2 = .73^*$$

where y is estimated mortality (percent) and x is the percent of crown scorched. For hardwoods the equations are:

$$\text{for trees} \leq 5''\text{ dbh};\ y = 49.248 + 4.911x;\ R^2 = .69^*$$

$$\text{for trees} \geq 5''\text{ dbh};\ y = 11.861 + 5.070x;\ R^2 = .75^*$$

where y is estimated mortality (percent) and x is the height of bark scorch.

Wildlife. Although recognizing that wildlife is valuable for many noneconomic reasons, the researchers assumed that most of the economic value is associated with outdoor recreation, primarily hunting for game species. This value can be estimated using available figures for the average expenditure per day of hunting for each species.

If a fire occurs in a cover type important to deer, small game, or waterfowl, the economic loss and/or benefit is estimated with the formula:

$$\text{loss or benefit} = \text{use change} \times \text{wildlife loss or benefit factor.}$$

Use change is a measure of the effective area burned.

Wildlife loss and benefit factors are the product of 1) the success index (a ratio of use per acre in a particular county compared to the average use per acre in Wisconsin), 2) the average expenditure for a day spent hunting a particular species (*4*), and 3) the effect of the wildfire on game populations (the full effect is the change in game expected if all trees died). An example of loss and benefit factors from the southern region of Wisconsin is given in table 1.

Recreation. The effect of wildfire on developed recreation sites is based on an estimated number of visitor groups who would have used the site for various recreational activities from the time of the fire to December 31. The values per group lost, based on a survey of expenditures in 1969 (*5*) and inflated to 1980 dollars, were: sightseeing—\$29.74, camping—\$28.30, fishing—\$26.43, picnicking—\$21.64, boating—\$17.86, hiking—\$17.14, and swimming—\$12.06.

The Wisconsin system also provides a procedure to determine the relative impact of wildfire on esthetics. Variables that influence esthetic values are the size of the area burned, the intensity and duration of the fire effects (related to tree mortality), and the esthetic importance of the area. Esthetic importance is rated as follows: IF a site that cannot be seen from any road, trail, lake, or stream is burned, the esthetic effect is in the lowest category. On the other hand, a large, severely burned site near a lake that has public access and is visible from a four-lane

*For grouped data.

highway would be rated the highest in relative esthetic importance.

Ornamental Trees. It has been difficult to appraise the effects of wildfire damage to ornamental trees (trees visible from and within 100 yards of a lake, home, or developed recreation site). The Wisconsin system appraises small trees and shrubs at current replacement cost. The system estimates the value of each large tree or each group of similar trees by using the following formula (*3*):

Value = base value
× species factor × condition
factor × location factor

Wisconsin currently uses the base value $16.56 per square inch.

Each species is assigned a factor of .25, .50, .75, or 1.0 according to the desirability of the species as an ornamental.

The condition factor is a relative rating (between 0 and 1) of the health, form, and vigor of the affected tree.

The location factor assesses the importance of the ornamental tree in the landscape and ranges from a rating of 0 for one of a group of trees at the forest edge of a developed site to 1 for a single specimen on a key site.

Table 1.—*A sample of wildlife benefit and loss factors in Wisconsin by county*

Sample counties	Deer[1]		Small game[2]			Waterfowl[3]	
	Benefit	Loss	SB,BW	A,PJ	OF	Benefit	Loss
				Dollars/acre			
Columbia	308.71	214.38	2.60	1.98	12.21	15.52	3.10
Dane	58.80	34.12	6.64	10.34	6.99	5.57	1.11
Dodge	19.60	11.37	12.49	14.02	24.67	36.76	7.35
Fond du Lac	58.80	34.12	12.49	14.02	24.67	36.76	7.35
Grant	19.60	11.37	1.02	1.98	—[4]	3.60	.67
Green	19.60	11.37	12.49	14.02	24.67	1.04	.21
Green Lake	308.71	214.38	6.64	6.94	24.67	36.76	7.35
Iowa	214.39	124.41	1.02	4.35	2.76	3.60	.67
Jefferson	19.60	11.37	6.64	6.94	12.21	36.76	7.38
Lafayette	19.60	11.37	12.49	14.02	12.21	1.04	.21
Marquette	308.71	214.38	1.02	1.98	—	15.52	3.10
Richland	143.34	83.17	6.64	10.34	—	1.04	.21
Rock	19.60	11.37	25.47	29.08	24.67	5.57	1.11
Sauk	214.39	124.41	6.64	6.94	—	3.60	.67

[1] Benefits to deer result when fires occur in white birch and northern hardwood stands or in jack pine or red pine plantations. Losses occur when fire is in a spruce-fir, black spruce, tamarack, or cedar type.

[2] Fire effects on small game are beneficial and result from fires in black spruce (SB), white birch (BW), aspen (A), jack pine (PJ), and open fields (OF).

[3] Waterfowl benefit from fires in marshes or open fields within .25 miles of water, and losses result if the fire occurs during the nesting season between April 15 and July 31.

[4] No small game benefit or loss in open field in this county.

Crops. With the New Wisconsin system, the loss of a crop or forage is evaluated by assessing the value of the expected yield (unless the crop can be replanted). If a crop can be replanted in the current year, the loss is the sum of the replanting cost and the value of the reduction in the expected yield due to a shorter growing season.

The following equation is used:

Crop loss = replanting
cost (if any) × acres
burned + yield loss
× price × acres burned.

Equipment and Improvements. Foresters assess equipment and other damaged items to determine those that need to be repaired (e.g., painting a cottage blackened by smoke) or replaced to restore the items to their prefire condition. Office personnel then consult blue books, contractors, and equipment dealers to estimate costs of restoring or replacing the items.

For more information

The new Wisconsin appraisal system is an attempt to balance theory with practicality and ease of use. After testing by field foresters, the system was revised and the reporting forms and instruction guide were streamlined. Most users were pleased with the new system and had little difficulty

in applying it. Although certain of the inputs such as hunter success indices and timber types or prices are specific to Wisconsin, comparable data for many Northeastern States are probably available and the basic format should be generally useful.

A detailed handbook describing step-by-step field data collection and office calculation procedures is now available from The Fire Research Unit, North Central Forest Experiment Station, USDA Forest Service, 1407 S. Harrison, East Lansing, MI 48823.

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Use of M-4 Fuel Thickener in Prescribed Burning

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The use of gasoline that has been gelled with M-4 fuel thickener was tried on summer site preparation prescribed burning on the Homochitto Ranger District, after reading McKee's and Ramberg's article in Fire Management Notes (Vol. 42, No. 1). Their article dealt with the use of hand-thrown devices ignited by type A igniter cord containing gelled gasoline. Because the terrain in southwest Mississippi is heavily dissected with rolling hills, summer site preparation prescribed burning requires extreme exertion by workers. Gelled gasoline in lightweight, easily thrown, and inexpensive devices assist in burning these areas and reduce the heat stress factor.

An inexpensive, hand-thrown device made with gelled gasoline, an ordinary freezer bag, and a fuse of igniter cord.

Inexpensive to make and use. The most efficient materials for hand-thrown devices using gelled gasoline are relatively inexpensive. Ordinary 1-pint capacity freezer bags from the local grocery store, which cost 45 cents for 30, and medium speed igniter cord, type A, which costs $11 for 300 feet can be used. A roll of igniter cord will make approximately 425 to 450 8-inch long fuses. Each fuse will cost about .023 dollars. The M-4 fuel thickener costs .07 dollars per pound. One pound effectively gells 5 gallons of gasoline.

On a typical 40-acre burn no more than 1.5 gallons of gelled gasoline has been used. This is enough to prepare approximately 85 hand-thrown igniters. The cost of supplies and materials to burn a 40-acre block using the hand-thrown igniter is 18 cents an acre as compared to 24 cents an acre with use of only the drip torch. The significant factor here is that ignition fuel consumption is reduced approximately 50 percent. Drip torches are a necessary complement to the job for burning out plowed lines prior to firing the block with the hand-thrown igniters, however.

Savings are the largest in personnel costs. Using drip torches requires a 6- to 9-person crew. Using handthrown igniters requires a 5- or 6-person crew—a reduction of 3 or 4 people. This reduction in personnel will reduce burning costs over $2 per acre. Cost per acre using drip torches has averaged $12 per acre.

Lightweight and easy to handle and throw. The use of approximately 2 tablespoons of gelled gasoline per freezer bag has proven to be just about the right weight for carrying and throwing. A 14-inch deep tree planting bag that will hold 35 igniters was used to carry the igniters. Total weight is

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slightly less than a fully filled drip torch. The planting bag can be worn around the waist, which aids handling by keeping weight closer to a person's center of gravity. Drip torches are carried at arm's length. The igniter weighs about 1¾ ounces and can be easily thrown distances of 20 to 30 yards down and across slopes. Any person qualified to prescribe burn can handle the igniters effectively. Inexpensive, disposable lighters are used to light the fuses. Even after burning 300 acres, lighter fuel supply remains.

Safe. M-4 is a powder, the consistency of light flour, that is very stable and can be stored in any ordinary storage area. Normal precautions should be followed in using gasoline. When preparing these devices, the gelled gasoline is placed in plastic bags, which eliminates fumes. Throwing these devices from a distance removes personnel from fire and sparks unlike using drip torches. Use of these devices allows personnel to follow the easiest routes through an area since firing is done from a distance. This greatly reduces exertion and fatigue. Since employees are not in close proximity to flames, chance of accidental ignition is almost nonexistent. An igniter cord does not spark but burns steadily. M-4 devices are not explosive; rather, they burn slowly but intensely.

Tips for use. To get acceptable results using these devices, one simple technique is necessary. During manufacture, the igniter cord should be wrapped around the outside of the bag, rather than stuck in the bag. Experience has shown that fuses stuck in the bags and tied have a tendency to smother out (candle in a jar situation). Fuses wrapped around the outside burn cleanly, penetrate the plastic, and ignite the gelled gasoline nicely. Ignition rate has been over 95 percent.

Fuel continuity is also very important. The devices are essentially for spot firing and require continuous fuels to be effective. Heavily logged areas dissected by skid trails or areas with light and discontinuous surface fuels will create some problems since isolated areas are easily missed. Chopped areas, windrows, or areas logged primarily from ridgetops are the ideal conditions. Throwing fire to isolated areas rather than trying to physically cover each of these areas with a handheld drip torch, has been effective in Mississippi.

Some bags of gelled gas have burst, generally in the bottom of the sack. This has always been limited to one or two. This is not particularly inconvenient since the gelled material stays in mass and does not run or leak all over everything. But by being careful not to wrap bags too tightly, this mishap can be avoided.

Conclusion

Very intense fires can be generated using hand-thrown bags of gelled gasoline, depending on burning conditions, fuel types, and fuel type continuity. Fires generated by this type of device generally take slightly longer to develop than drip-torch generated fires because they are one point ignition fires rather than continuous string or line fires. Intensity of the fires produced by each method is virtually identical.

Spot firing can be very effective in the type of terrain found on the Homochitto, which makes it very hard for burners using drip torches to keep up with each other while firing out the interior of the burn, since the burners are almost always out of sight of each other. Several situations have developed under very "hot" burning conditions where the possibility of becoming trapped by the fire from another line was quite possible. Spot firing eliminates this possibility because of the time lapse required for the fire to gain momentum. By firing off of ridge tops, personnel can more easily keep up with each other and have an easily available escape route.

This ignition technique is not revolutionary; however, it is extremely useful in rolling to hilly terrain like southwestern and northern Mississippi. People using this concept will still have to do some experimenting to find what works best for their situation. Proper timing and type of fuels each play a very important part in the application of this technique. Through proper coordination with burning criteria, acceptable on-the-ground conditions, and paying close attention to the details of the burn, burning personnel should find this one of the most easily applied ignition techniques for site prepared burning. ■

New Release

The costs and effectiveness of fire management programs on six National Forests are briefly analyzed in a new 29-page report from the Pacific Southwest Station. Dennis L. Schweitzer, Thomas J. Mills, and Ernest V. Andersen of the Forest Service prepared *Economic Efficiency of Fire Management Programs at Six National Forests*, Research Paper PSW-157, and examined the costs of initial attack and aviation programs on National Forests in Oregon (the Deschutes and Willamette Forests), in California (the San Bernardino), Arizona (the Tonto), South Carolina (the Francis Marion), and Michigan (the Huron-Manistee).

The purpose of the study was to see how variations in funding might affect the success of the firefighting programs. Schweitzer, Mills, and Andersen used four budgets for initial attack and air operations. The test involved pitting these programs against a sequence of computer-simulated wildfires designed to represent two to three "light" through "severe" fire years.

The study focused on two effects: the cost of putting the fires out (fire suppression) and the fire-related changes in the value of the natural resources and structures (such as buildings and dams) that the initial attack and air operations were supposed to protect.

The analysis showed that the lowest funding levels for the initial attack and for air operations for the initial attack were the most economically efficient on four of the six Forests. Also, on four of the Forests, the severity of the fire year did not affect the economic efficiency of the program. The authors report that increased fire year severity may not mean higher program levels are more efficient.

The fire year simulations further showed that fire suppression costs went down as initial attack and aviation funds went up, which is in strong contrast to the historical rise in suppression costs that occurred at the same time that presuppression budgets were increasing. ■

Smokey Bear—A History of Success[1]

A strong nationwide effort in wildfire prevention was begun in 1942. It was a cooperative project from the beginning, with State Foresters, the Wartime Advertising Council, and the Forest Service involved. A poster featuring Smokey Bear was circulated in 1945. This symbol soon became very popular. In fact, a recent survey showed "Smokey" is a known symbol to almost all Americans.

Canada and Mexico also participate in the Smokey Bear fire prevention program. The Canadian Forestry Association is the official agent in that country for Smokey Bear publicity materials, and it distributes them to the provinces. Mexico uses the "Bear" symbol, calling him "Simon El Oso" (Simon the Bear). . . .

The Smokey Bear program has been one of the most effective campaigns in history using an animal symbol to influence public opinion favorably in combating a serious national problem. Since the campaign began, wildfires have dropped dramatically both in number and in total area burned. Smokey has proven both an authoritative and a lovable figure.

The slogan, "Only You Can Prevent Forest Fires," coined in 1947, has proven so effective that it is still used regularly in posters, radio and television public service announcements, ads, flyers, and the like. Since it was found that young children playing with matches start many forest fires, a companion theme was added to Smokey's Cooperative Forest Fire Prevention Program. It is "Smokey's Friends Don't Play With Matches." It, too, has been effective. These messages are taken very seriously by children, who often chide their own parents for bad habits with fire.

To give youngsters the feeling of direct participation in preventing wildfires, a nationwide Smokey Bear Junior Forest Ranger program was developed in 1953. Most ranger appointments are made at Smokey Bear headquarters in Washington, D.C. 20052. But some State forestry agencies cooperate by distributing these kits in their areas.

All 50 States participate in the cooperative prevention program through State and local forestry, park and fire management agencies, and agencies in the U.S. Department of the Interior, as well as other Federal departments with extensive landholdings.

Outdoor sports, conservation, service, and youth organizations, and their State and local affiliates also cooperate as do forest industry groups. ■

[1]Reprinted from: You and Forest Fires. PA-64. Washington, DC: U.S. Department of Agriculture; 1980:10-11.

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